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Society for the Encouragement of Arts, Manufactures, and Commerce.

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CANTOR LECTURES. 90

THE

APPLICATION OF PHOTOGRAPHY

TO THE PRODUCTION OF

PRINTING SURFACES & PICTURES IN PIGMENT.

SIX LECTURES

DELIVERED BEFORE THE SOCIETY,

BY THOMAS BOLAS, F.C.S.

Reprinted from the "Journal of the Society of Arts."

LONDON:
PRINTED BY WILLIAM TROUNCE, 10, GOUGH-SQUARE, FLEET-STREET, E.C.
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THE APPLICATION OF PHOTOGRAPHY TO THE PRODUCTION OF PRINTING SURFACES AND PICTURES IN PIGMENT.

Lecture I.—Delivered February 18, 1878.

Photo-Lithography and Photo-Zincography.

When a photographer wishes to take a picture, he, as a rule, begins by making what is technically known as a negative; this being a transparent picture having the lights and shades reversed. Now, here is a negative; as I hold it before the lime-light you see that the parts corresponding to the dark portions of the original are transparent, and those parts which correspond to the lights of the original are opaque. Here, on the other hand, is a positive, or transparency, of the same subject as the negative which you have just seen; the lights and shades of this being as those of the object represented. A negative taken from nature should show the reverse of all those gradations of light and shade which characterise natural objects, while a negative taken from a line engraving or a page of letter-press should show only two gradations, complete opacity and clear transparentness. Here is such a negative; and notwithstanding the fact that the opaque parts are not quite opaque to the sight, they are chemically opaque, that is to say, they will not allow the photographic rays to pass through. I have nothing to say to you regarding the making of negatives, as this matter belongs to photography proper, and not to our present subject.

Here is a sheet of paper which has been so prepared as to become darkened on exposure to light; let us place this behind our negative, and allow the light of burning magnesium to shine on the face of the negative. You see the result. Those parts of the paper which were covered by the transparent parts of the negative have become dark, while those parts which were protected from the light by the opaque parts of the negative retain their original white colour. Thus a positive print is obtained on paper; but if the paper print be now exposed to daylight the whole will become dark, the picture, consequently, disappearing.

This operation illustrates the first phase in the process of photographic printing as usually practised, the next step being that of unsensitising the paper, so as to prevent the complete darkening which would otherwise ensue on the further exposure of the print to light. Our object now is to study the means of producing printing surfaces (plates or blocks) from which copies can be printed without the direct action of light being concerned in the production of each print.

The piece of yellow paper which I now hold in my hand is sensitive to light, and I will place it under this negative of a line drawing, and expose to the action of an intense light. You observe that a very faint brown image is now produced on the sensitive paper by the action of the light shining through the transparent parts of the negative; and I now hide this from your view by covering the face of the paper with a thin and uniform layer of printer's ink. For this purpose the ink is diluted with a little oil of turpentine, and applied by means of a dabber, made of the glue and treacle composition which typographic printers use for making ink-rollers. The oil of turpentine soon evaporates, and leaves a compact and thin film of printer's ink on the paper. I next put the inked print into water, and leave it there while I tell you how the sensitive paper was prepared. A sheet of plain paper is first floated on this warm solution of gelatine (containing six per cent. of gelatine), and it is then hung up to dry (as I do now). When dry it is insensitive to light, and it may be kept any length of time without injury. To make it sensitive to light it is soaked for a few minutes in this solution of potassium bichromate, which contains about 3½ per cent. of the salt, and it is once more hung up to dry, but this time in a dark room, or in a room illuminated by yellow light. When dry, it is ready for exposure under the negative.

Let us now return to the inked print which we left soaking in water, and try the effect of gently brushing the inked surface with a wet camel's-hair brush. You see that the ink is gradually coming off, but in order to save time let us employ a little warm water, and, at the same time, continue to use the brush. Now the end of the matter is, that the printers' ink becomes removed from all those parts of the paper which were not exposed to the action of light, and an image in fatty ink is thus obtained on the gelatinised paper. From this I now remove the excess of water by means of blotting paper, and lay the print, inked face downwards, on a clean and slightly warm lithographic stone. The stone and paper being now passed through the press, you see that the paper adheres firmly to it, but on moistening the paper with a sponge it becomes easily removable. Now I strip it off, and you see that the fatty ink is fixed on the surface of the stone, leaving a perfect but reversed image thereon. Remember that this image consists of fatty printers' ink, and that it penetrates a short distance into the porous stone. Next, I put some thick gum water on the stone, and this also penetrates a short distance into those parts of the stone not already covered with printers' ink. I now rinse off the excess of gum and apply the inking roller; you see that the ink only adheres to

those parts already inked, the gummed parts resist the ink, and consequently remain white. A sheet of paper being now laid on the stone, I now pass the stone and paper through the press, and you see that I get an exact counterpart of the original fatty image (technically called a transfer) which was put down on the stone. Numerous copies may be printed from the stone by repeating the damping and inking.

You will recollect that when the light brown image was inked with printers' ink, the ink covered the whole face of the paper; but when this inked image was put into water, the ink became easily removable from the unexposed parts. Now, gelatine which contains potassium bichromate, undergoes a remarkable change when exposed to the action of light. It not only becomes brown in colour, but it loses its property of swelling in water, and, at the same time, it refuses to be moistened; in fact, water rolls off it just as from a duck's back. Now, when the inked print (transfer) is put into water, the unexposed parts of the bichromated gelatine swell, and loosen their hold on the fatty ink, while the exposed parts neither swell nor absorb water, but hold the ink firmly. In this dish are some uninked transfers, which have been soaked in water, and if you examine them closely, you will be able to trace those parts of the gelatine which have swelled, leaving, in each case, a delicate *intaglio* image, or representation, of the negative employed.

Instead of putting the photo-lithographic transfer down on a lithographic stone, it may be put down on a zinc plate, and the plate can be printed from, if treated exactly as the stone was treated. There are on the table some zinc plates and stones, with images transferred thereon, together with proofs from them; and there are also specimens illustrating the various phases of photolithography and zincography. Messrs. Whiteman and Bass, who have been most successful in the commercial practice of photolithography, have kindly lent me some very fine specimens of their work, which I am sure you will examine with much interest. There are also on the table some admirable specimens of work by Mr. Maurice Adams.

You understand that, in its usual form, photolithography is only adapted for the reproduction of line subjects, or subjects in extreme black and white, and various attempts have been made to render it available for the reproduction of the gradations of a negative taken from nature. By a modification of Asser's starch process I have been enabled to get results which are at least encouraging. Here is a sheet of blotting paper, which I now cover with ordinary flour paste, containing 8 per cent. of flour. The paper having been coated, it is next smoothed with a soft badger brush, just as I am doing now, and when dry the paper is soaked in a $3\frac{1}{2}$ per cent. solution of potassium bichromate, in order to make it sensitive to light. This piece of the sensitive paper being placed under a negative, and exposed to the light of burning magnesium for a few minutes, soon becomes tinted with a brown colour where acted on by light, as you see. The light brown print is next soaked in cold water, in order to remove the unaltered portion of the potassium bichromate, after which it is dried and ironed with a warm flat-iron, just as I am ironing this one. This last operation is to harden the coating. I now put the ironed print into water, take it out, lay it on blotting paper, and dab on printers' ink with a stiff brush. You see that the ink adheres to those parts where the bichromated paste has been made insoluble by the action of light, and it refuses to adhere to those parts where the paste remains soluble. In this way a fatty transfer is obtained, which, as you see by these examples, shows all gradations of a negative taken from nature, not, however, as a true half-tone, but as a grain or stipple well adapted for transferring to stone or zinc. As a fine image of this kind is liable to get clogged up when printed from stone, it is better to transfer it to a plate of zinc, and to make a typographic block from this by the method which I shall describe in a subsequent lecture. In the interval I will convert this zinc plate into a typographic block, and you will be able to compare these proofs, printed by the lithographic method, with others which I will take from the typographic block.

I hope some of you will experiment on Asser's process, with the view of improving it, as this method affords a promising field for work, it being specially adapted for large pictures.

Lecture II.—Delivered February 25, 1878.

Phototypic, or raised Printing Blocks, by Swelled Gelatine Process, Zinc Etching, and other Methods.

Here is a fatty ink transfer, similar to that which I put down on a lithographic stone during the first lecture. I now lay it on a smooth and clean zinc plate, and pass through the press. On removing the paper, by soaking, we find that the ink firmly adheres to the zinc, just as it previously did to the stone. A treatment with gum now protects the clear parts of the zinc plate against the adhesion of printing ink, and the application of the ink roller adds more ink to the fatty image already on the surface of the zinc plate. So far, our present process resembles the photo-lithographic process described last week; but, instead of printing from the zinc plate, I dust powdered resin over it, in order to give firmness to the fatty image, very slightly warm the plate, to make the resin and ink partially blend, and then put it into dilute nitric acid, containing one part of acid to about forty parts of water. Here it remains for about three minutes, during which time the acid dissolves away those parts of the metal which are not covered by the waterproof coating. Now, let us take the plate out and examine it. We find that the covered parts stand slightly in relief, but only very little, and if we were to continue the etching without further preparation, the acid would gradually undermine the lines, and the image would be lost. Now, the undermining action of the acid can easily be prevented by washing the plate, drying it, and then heating it sufficiently to just melt the resin. Under these circumstances, the melted resin blends with the printers' ink, and runs down over the sides of the little ridges left by the etching, and protects these sides from the further action of the acid. Having done this, it is well to gum the plate once more, ink again, dry and dust with resin before proceeding to another etching. This second etching may be done with stronger acid than the first, say one of nitric acid to 30 of water, and it may be continued longer, say, for six or seven minutes, and when this second etching is finished, the series of operations must be repeated until sufficient depth is obtained, care being taken that the melting of the resin is only carried far enough to allow it to flow just over the sides of the relief left by the previous etching. In ordinary cases ten etchings are enough to give the necessary depth, but in the case of important work it may be necessary to give twenty or thirty very slight etchings in order to obtain the same depth, without endangering very fine lines or details.

On the table are some zinc plates illustrating the various stages of the process, and there are also some admirable specimens of finished work by Messrs. Leitch and Co., and by Messrs. Dellagana and Co.

The process of zinc etching has been largely employed for the production of typographic blocks from fatty transfers, either drawn by hand or printed, and this phase of the process bids fair to compete successfully with the art of wood engraving.

There are other methods of producing phototypic blocks, among which may be specially mentioned the method which is founded on the swelling of gelatine. These admirable phototypic blocks, which Mr. Dallas has lent me, are done by a method which he has perfected, but the nature of it has not been made public. Mr. Dallas was the first to introduce phototypic blocks into the English market, and if you carefully examine some of his specimens you cannot fail to be struck by the fineness and perfection of the details.

By the following modification of the swelled gelatine process I have succeeded in overcoming many of the difficulties of the methods already published.

We start with some clear sheet gelatine about one-thirtieth of an inch in thickness. This can be prepared by drying a layer of gelatine solution on a sheet of waxed glass, or it can be purchased from Mr. Cornelissen, of Great Queen-street. To make this gelatine sensitive to light it is soaked in $3\frac{1}{2}$ per cent. solution of potassium bichromate until it becomes flaccid, it is then laid on a piece of clean glass, and the excess of solution is removed by an application of the squeegee. The plate bearing the wet gelatine is then placed in a warm, and photographically dark, place to dry, and when dry it can be easily separated from the glass by raising one corner with a pen-knife. We obtain in this way a flat sheet of sensitive gelatine, having a smooth surface and all ready for exposure under the negative, and this exposure may last from ten to twenty minutes in sunshine or a correspondingly longer time in the shade.

I now take the exposed film and put it into water to soak, and you will perceive that those parts which were protected from the light begin to swell immediately, while the exposed parts refuse to swell in the water. The soaking should last several hours, but as we cannot spare that time I will take a gelatine which has already soaked the necessary time, and make a cast from that. For this purpose I lay the wet gelatine film on a piece of glass, exposed side upwards, and squeegee it down as before; you see that it adheres to the glass quite easily, and after having made it surface-dry by dabbing with a soft cloth, a little oil is applied, and distributed over the surface. Now, that the excess of oil has been removed by a soft cloth, I pour on plaster of Paris to a thickness of about an inch, taking care to remove any air bubbles by the application of a camel's hair brush through the liquid plaster.

Now, this plaster will take about ten minutes to become solid, so let us take another one, which

was cast just before the lecture, and which is now set. If we violently tear the plaster and the gelatine apart, the fine details of the cast are almost sure to be damaged. But instead of doing this, let us hold the glass plate in one hand, and gently push the plaster cast with the other. Now you see that the gelatine is slowly sliding over the glass, and finally it will slide quite off, the gelatine still being adherent to the plaster. It is now merely necessary to turn up one corner of the gelatine film, and slowly fold it back so as to draw it off the plaster gently, and without fear of damage, either to the gelatine relief or the plaster, just as a lithographer draws a thin paper proof from the stone. The next step is to make a cast in stearine from the plaster, and for this purpose the plaster should be soaked in rather warm water, about 50° Centigrade, and on this soaked and warm plaster, just as I have it here, a layer of stearine about an inch thick should be cast. Such a cast takes a long time to cool, so I have provided myself with one previously done. There it is; see how easily the stearine separates from the plaster. I now dust the stearine cast over with bronze powder, the best being a kind specially manufactured by Mr. Allen, of Mansfield-place, Kentish-town; and, this done, I put the cast into the electrotyping bath, and when a sufficient quantity of copper has been deposited it is merely necessary to back up with type metal and mount on a wood block, as in the case of this example, our work being then ready for the typographic press. If the process I have described is gone through with an ordinary half-tone negative, an exceedingly beautiful electrotype is obtained, in which the gradations of light and shade are represented by varying degrees of relief. These, or even plaster casts, ought, I think, to have a very good sale, if photographers would only take the matter up. The ease with which they can be made is surprising.

I may mention that, instead of taking a cast from the plaster in stearine, gutta-percha may be used, a press being employed to force the plaster cast—which should be in an iron chase—into the soft gutta-percha. Here is a cast, and here a piece of soft gutta-percha. I now put them into the press, and apply pressure, and in a minute you will see what a good impression it is possible to get by this means. Of course, electrotyping on the gutta-percha is very easy, but the examples on the table will illustrate the matter sufficiently.

The depth of the relief obtainable by the swelled gelatine process is about equal to that of an ordinary visiting card, and, where large surfaces of white occur, it is necessary to deepen the plate in these parts. This may be done either by cutting out the metal from the finished plate, or, in most cases, more conveniently by raising the surface of the mould, let it be wax, stearine, or gutta-percha, on which the electrotypic copper is to be deposited. This is best done by holding a stick of stearine or wax in the left hand, and a warm pencil of metal in the other hand, and so holding the wax or stearine as to let a thin melted stream flow down the warm pencil. This stream is allowed to flow on those parts of the mould which require raising.

Most commercial phototypers content themselves with producing a very slight relief by photography proper, and they then deepen by hand work.

Lecture III.—Delivered March 4, 1878.

Line Engraving on Metal Plates.

We now go back to the first photographic process discovered—that is to say, the first process which gave photographic representations which could be exposed to light without destruction—the bitumen process of the hard-working and patient Niépce. This investigator noticed that the residue left on the drying of certain varnishes became insoluble by exposure to light. About the year 1814, he covered metal plates with a bituminous varnish, exposed them in the camera obscura, and after exposure he subjected them to the action of similar solvents to those originally employed in making the varnish. Under these circumstances those parts of the film which had been exposed to strong light refused to dissolve, while the unexposed parts dissolved, a negative image being thus formed on the metal plate. To convert this negative image into a positive, those parts of the metal which were uncovered by bituminous matter were darkened by the vapour of iodine, and the bitumen was then removed by the use of a more powerful solvent. By the application of a suitable acid to the bitumen pictures on metal, the bare parts were dissolved away, and engraved plates were obtained. Here is a specimen of bitumen or mineral pitch—a substance which is found in most quarters of the world. Let us powder a little, and pour benzole on it; you see that it dissolves quite easily, and the solution runs freely through this paper filter. You see that the solution is about as thick as collodion, or perhaps, rather thinner. Now, here is a carefully cleaned copper plate, such as the engravers use, and you see that I am going to clamp it down on to this

turn-table. The next step is to flood the plate with bitumen solution, and then to make the table revolve quickly. Now it has revolved a few seconds, and I think the film will be dry. Here it is; I hand it round, so that you can judge for yourselves as to the advantages of this method of coating the plate. I know of no other method by which such a uniform and compact film of bitumen can be obtained. After coating, it is well to put the plate aside for twelve hours, in order that the film may become harder. It is then necessary to dust it over with French chalk, to remove stickiness; and, after this, it is placed behind a transparency, and exposed to light. The time of this exposure may vary from twenty minutes to two days.

Here is a plate which has had the requisite exposure, and the next matter is to dissolve away that portion of the bitumen which has not been made insoluble by the action of light. Now, benzole is too energetic a solvent for my purpose, and oil of turpentine is not sufficiently active; but, by mixing these together, you can get any degree of solvent power which you may require. I will get Mr. Barker to treat this plate with the solvents. You see that he commences by flooding the plate with oil of turpentine, and, as this has not sufficient action, he pours it off, and adds a little benzole; this begins to produce an effect, and enables him to judge as to the amount of benzole which he may safely add to the oil of turpentine. He has added this quantity, and has now washed away all the soluble bitumen from the plate, which is next thoroughly rinsed with water to remove the oil of turpentine. You see how extremely sharp and well-defined the lines are. I next place the plate in nitric acid, so as to etch the lines where the metal is bare; and while the etching is in progress, I will get Mr. Barker to dissolve away the soluble bitumen from this glass plate, when we shall find remaining the bituminous reproduction of a page of letterpress, which I can show you by means of the lantern. Our first plate is now sufficiently etched, and when I have cleared off all the bitumen, by rubbing with a rag and benzole, the plate will be ready for the printer. It is now clean, and I will hand it round for you to examine.

Mr. Barker has the bitumen image on the glass plate, ready for the lantern; the image is now on the screen, and you see how sharp and well defined the lines are; I take the plate out, and if you examine it, you will notice that the letters are raised on the glass—they being, as you know, formed of insoluble bitumen. If we wish to etch the glass, it is merely neccesary to expose it to the action of hydrofluoric acid, as I do now.

So much for the line-engraving process of Niépce; but before you go I want to show you that very perfect half-tone transparency pictures may be produced by means of bitumen. Here are some pieces of sheet gelatine, and some pieces of talc, which have been varnished on one side with bituminous varnish. I hold two of these, one being on talc and the other on gelatine, over against the lime-light, and you merely see even films of bitumen, but no image. There is, however, in each case a picture of insoluble bitumen imbedded in the films, and I will get Mr. Barker to dissolve away the soluble portions, so as to lay bare this hidden image. He will use a mixture of oil of turpentine and benzole as a solvent.

Supposing that the varnished side of the talc or gelatine is placed in contact with the negative, and the light is allowed to shine through it; those parts of the bitumen film which are under the perfectly transparent parts of the negative become insoluble, let us say, all through. Now, those parts of the film which are under less transparent parts of the negative, do not become insoluble all through, but a skin of insoluble bitumen is formed on the surface of the bitumen film, this skin varying in thickness according to the amount of light which has given rise to it. Put a varnished and exposed gelatine sheet of this kind into the solvents, and note the effect. When the film is made insoluble all through, it resists the action and remains on the talc; but where only a skin of insoluble bitumen exists on the surface of the film, the solvents loosen and dissolve the bitumen from underneath this skin, and away it floats. Now you can understand why the bitumen process, in its ordinary form, is only adapted for the reproduction of subjects in extreme black and white, such as line engravings or letterpress. If we wish to preserve the half-tone picture intact, we must expose through the transparent medium (talc or gelatine) so as to ensure every part of the insoluble image, whatever its thickness, being in contact with the transparent support. Those prints which Mr. Barker is developing were done in this way, the talc or gelatine being placed in contact with the negative. The small thickness of talc or gelatine does not render the image notably unsharp. It was only during the last week that I thought of making bitumen transparencies by this method of printing against the back of the film, so I have not had time to make many examples. Mr. Barker has now finished the washing away of the soluble bitumen from those which he took in hand some minutes ago, and as I exhibit them on the screen, you will see how perfectly all the gradations of half-tone are represented. You quite understand that a picture of this kind is solid, the gradations of light and shade being due to a greater or less thickness of bitumen, and that the essential points in producing them are to varnish a thin, transparent medium with bitumen, to expose to light through this medium, and then to dissolve away that portion of the bitumen which has not been acted on by light. The ordinary black varnish sold for backing glass positives will answer very well, and so will some samples of Brunswick black. Here is a transparency which was made with ordinary Brunswick black; remember, however, that some samples of Brunswick black are not sensitive to light, these being probably made with coal pitch.

I think that by the method which I have just indicated, very fine lantern slides may be produced, as there is an entire absence of texture or granularity, and it is probable that the bitumen pictures may be stained or toned without difficulty.

On the table are some plates and specimens illustrating the process of engraving on bitumenised plates, and you will specially notice the great clearness and sharpness of the lines produced by this method. Messrs. Leitch and Co. have kindly lent me some of their photo-engraved plates, which you will examine with much interest. These

copper plates have been covered with a thin film of iron, by the electrolytic method, and as the film of iron is extremely thin, it does not in any way interfere with the printing qualities of the plates. When the surface of a plate begins to wear a little, and the impressions show signs of deterioration, the plate is sent back to Messrs. Leitch and Co.'s factory, where the film of iron is dissolved off by means of dilute sulphuric acid, leaving the copper plate as good as ever. The film of iron, although so thin as not to injure the printing qualities of the plate, is nevertheless sufficiently thick to protect the copper from injury in printing. The plate having been freed from the first worn-out film of iron, is once more coated with a layer of iron, and is again ready for use. When the second film of iron is nearly worn away, and the printer approaches near to the true surface of the copper plate, the iron is again dissolved away, and a new coating of iron is put on. According to this system, one really prints rather from a cast of the plate than from the original plate, and new casts are made as required.

Here are some admirable specimens of photographic engraving by Mr. Dallas, a gentleman who is always to the fore in matters connected with photo-mechanical printing.*

Before you go I wish to call your attention to a very simple and expeditious way of making engraved plates from line subjects. Here is a photo-lithographic transfer made from a positive, instead of from a negative, as is usually the case. You see that the ground is black, and the lines are white; in fact, by far the greater part of its surface is black. I now lay it on a zinc plate, and pass it through the press. Now, what will be the result? I will tell you beforehand. So much of the paper being covered with printing ink, and so little being white, moist, and gelatinous, the transfer will slide over the zinc plate, and we shall merely get a smear. Here it is. I have here another transfer similar to the last, excepting that white patches are introduced on it wherever they can be introduced without falling foul of the picture. This is done by painting on the transparency with Brunswick black. On putting this transfer down on a zinc plate you see that it adheres properly, and we have a perfect image on the metal. As the white patches are now done with, I varnish them over, and you see that the zinc is covered everywhere except where the lines of the engraving are bare. The covering on the zinc is now made denser by inking and dusting with resin, as I explained in the last lecture, and the plate is then etched by dilute nitric acid. Here is a plate all ready inked and dusted; I place it in this dish of nitric acid, and allow it to remain a few minutes. I now clean off the ink, and you see the lines are engraved on the zinc plate. The plate may now be printed from in the copper-plate press, or, as zinc is not a convenient metal for deep plate-printing, it may be reproduced by the electrotype process.

Lecture IV.—Delivered March 11, 1878.

Printing of half-tone subjects from metal. Application of Asser's process. Talbot's Photo-engraving. Woodbury's methods of engraving and printing.

When treating of photozincography, I gave details of Asser's process, and I showed you a zinc plate bearing the fatty image. Since then I have etched that zinc plate, so as to convert it into a high printing block, suitable for the typographic press. Here it is; here is an electrotypic cast of it; and yonder is a proof from it, hanging side by side with a proof from the unetched plate. In comparing these proofs, you will see that a little of the detail has been lost during the etching; but this is not due to any defect in the process, but to the fact that I etched the plate too rapidly. In etching a plate of this kind, the re-inkings must be done with great caution, and the acid used for the earlier etchings must be very dilute—say, one part of acid to one hundred of water.

I hope to see Asser's process come into use for large and comparatively rough work, it being well adapted for this. Mr. Dallas has brought the manufacture of typographic blocks, for the representation of half tone, to great perfection, and he has kindly lent me some of these, and also prints from them. Although we do not know what method Mr. Dallas employs in making his "tint" blocks, we can all appreciate the excellence of the results.

The illustrious Talbot discovered a method of printing in half tone by means of etched copper or steel plates, and very beautiful results have been obtained by his method, which I now intend to illustrate to you.

Here is a copper plate which has been carefully cleaned and charcoaled. I slightly warm this, and fix it on the turn-table. I next pour on it a warm

* After the lecture, Mr. Dallas informed me that he has been in the habit of coating the surface of his plates with iron, as described above.—T. B.

solution containing six parts of gelatine, one hundred of water, and one of ammonium bichromate. The table being now rotated, all excess of the gelatine solution is thrown off, and a thin even film is left on the copper plate. The plate must next be dried at a gentle heat, after which it is ready for exposure to light under a transparency. Here is a plate which has been so exposed, and you will notice that, where the light has acted, the coating has become brown, and at the same time it has become insoluble in aqueous liquids, the degree of insolubility depending on the extent to which the light has acted. The next problem is to etch through the soluble parts of this film without destroying its continuity. This cannot be done by nitric acid, as the acid destroys the gelatine film at once, but a strong solution of iron perchloride will answer the purpose. The plate being now put into this solution of perchloride of iron, the etching has commenced. Those parts of the gelatine film which have not been acted on at all by the light remain very soluble, and allow the etching to take place rapidly, while those parts where much light has acted resist the solution altogether, and those parts which have been acted on by a small proportion of light allow a proportionate amount of the iron perchloride to penetrate. Thus all degrees of light and shade are represented by corresponding amounts of etching. The plate is now sufficiently etched. I take it out, clean off the gelatine; and now it is ready for the press. Here is a proof from a similar plate.

The next process to which I direct your attention is one discovered, perfected, and carried out on a large scale by Mr. Woodbury. The Woodbury-type process consists in casting coloured gelatine pictures in a metal mould. Here is a metal mould—the method of making it I will describe directly—in which the image is hollowed out, the depth of the hollow being greatest in those parts corresponding with the dark parts of the picture, and everywhere deep in proportion to the intensity of the shade. I place this mould in a dish containing blackened water, so that the water just runs over its face. You now see no picture or anything approaching to a picture. Now notice the effect of pressing a piece of plate-glass down on the surface of the mould. The excess of blackened water is forced out, and the hollows of the mould alone are filled up with the blackened water. Now, as these hollows vary in depth, varying degrees of shade are produced, and a perfect picture is produced. I take the glass off, and the picture disappears; put it on once more, and it re-appears. Instead of coloured water, I pour on this mould a little coloured gelatine, and press a piece of plate-glass down on the surface. The excess is forced out, and the mould filled with coloured gelatine. In a few seconds the gelatine will have set, and I shall be able to lift off the glass, which will carry with it the gelatine image. Here it is; it forms a transparency suitable for the magic lantern. If, after having flooded the mould with coloured gelatine, a piece of paper is laid on, and the excess of gelatine is forced out with a plate of glass, a picture composed of coloured gelatine is moulded on the paper, and can be removed as soon as the cast is set. When removed, it is dipped into a solution of alum, in order to render the gelatine image insoluble in water.

So much for the general principles of Woodbury-type; and now let me show you how you can work this process yourselves.

The first thing is to dissolve about six parts of easily soluble gelatine, and two parts of lump sugar, in fifteen parts of warm water. Here is the warm mixture already strained through muslin, and here is a waxed glass plate, set level, and bordered with a little ledge of wood. The warm gelatine solution being poured on, spreads itself over the plate, forming an even layer, which, in the course of some hours, will dry, forming a uniform sheet. Well, here is a dry sheet of the gelatine on another piece of glass, and you see that the introduction of a penknife under one corner of the gelatinous sheet brings it off the glass at once. The next thing is to make this gelatine sensitive to light, and for this purpose it is soaked in a solution of potassium bichromate, containing $3\frac{1}{2}$ per cent. of the salt. You see that it has now become quite flaccid by absorbing the solution, and I now lay it on a sheet of glass, and remove the excess of solution by means of the squeegee. The bichromated gelatine adheres to the glass, but when dry it will be easily removable.

Here is a glass plate, with a dry sensitive film on it. I take the film off, and place it under a negative. It is now ready for exposure to light, and would require about two hours of such light as we had to-day at noon. Here is a printing frame containing three such films, which have had the necessary exposure under their negatives. I put these films in water, and let them get moderately soft, but not so soft as the film became during the sensitising. One of these I take out and lay face downwards on a piece of finely ground glass, another is similarly placed on a piece of glass covered with gold-beaters' skin, and the remaining one is put down on a sheet of collodionised glass. The squeegee is now applied to each, and adhesion takes place. In order to enable the gelatine films to firmly fix themselves to the supports, they should remain at rest during a period of about half an hour; but as we cannot wait that time, I have provided a duplicate set previously prepared. Mr. Barker will now put these into warm water, and the gelatine soon begins to dissolve. Now, remember that certain parts of the bichromated gelatine have been made insoluble by the action of light shining through the negative, and these insoluble parts will remain undissolved on the supports (ground glass, gold-beaters' skin, and collodionised glass). It will take some little time for Mr. Barker to wash away all the soluble gelatine, but towards the end of the lecture you will see his results in the shape of gelatinous reliefs; thick where corresponding to the blacks of the picture, very thin in those parts representing the whites, and finely graduating between these extremes. When the reliefs have been sufficiently developed, they must be dried, and here is a finished and dry set. You see that, having only one hour, it is necessary to get continually in advance of the work, and to take fresh materials which have been previously worked up to a certain stage. Let me begin with the relief on finely-ground glass. This being gently warmed, I put a border of wood round it, and pour on some fusible metal, made by melting together

one part of cadmium, two parts of tin, four parts of lead, and seven parts of bismuth. Well now, if I left this to cool in the ordinary way, the top would solidify first, and the lower layers of metal in contracting would leave small vacant spaces next to the surface of the gelatine, thus rendering the cast imperfect. To obviate this, I place the glass on this cold block of metal, and cover the top of the fluid fusible alloy with warm sand. The rest explains itself—the portion of fusible alloy next the face of the mould becomes solid first. Here is a fusible metal mould made in the way I have just illustrated to you; I oil it slightly, pour some coloured gelatine solution on it, and force away the excess by means of flat glass; and when the gelatine has set, the glass can be removed, carrying with it the moulded transparency.

Here is the relief on gold-beaters' skin, and here is the one which was developed on collodion. These can easily be stripped from their glass supports, as I now show you—one corner being liberated, off they come; I will pass them round for you to look at. Now, in the actual commercial practice of Woodbury-type printing, a film relief, such as you are now passing round, is forced into a plate of lead by means of the hydraulic press, and the leaden mould thus obtained is used for printing. I now lay a film relief on the smooth steel base of this screw press, place a piece of lead on the top, and apply pressure. You see the result—the lead has become an exact counterpart of the gelatine relief, which you will notice is in no way damaged.

Here is a leaden mould, together with the corresponding relief, kindly supplied by Messrs. Braun and Co., of Dornach, and here is a very fine mould made by Mr. Woodbury himself. I will make a cast in this, and you see that the result is one of Mr. Woodbury's magnificent lantern slides, which are now so popular. It is now projected on the screen, and you can all see it. I take it out, or the heat would melt the wet gelatine, and I pass it round for you to examine, but remember that it is not yet dry, so do not touch the face of it.

I think I explained to you that, in order to get a Woodbury-type picture on paper, it is merely necessary to interpose paper between the gelatine, as poured on the mould, and the plate-glass cover, which forces out the excess. To illustrate the matter, I will print one from this mould. Now, notice the paper I use. It is thin, hard paper, surfaced with shellac, to prevent the gelatine from penetrating it, and heavily rolled, to make it even in thickness. There is much more which I should like to tell you about the Woodbury-type process, but I have not time. You will not fail to notice the admirable collection of prints and illustrative specimens kindly lent me by the Woodbury-type Company, Messrs. Goupil and Co., Braun and Co., Bruckmann, and others, who are working the process on a large scale, not forgetting these very fine specimens lent by Mr. Woodbury himself.

I may mention that, in actual practice, one Woodbury-type printer can attend to several moulds, and by the time he has filled the last of the series, the first is ready to give up its picture. The moulds are arranged on a circular table, which revolves in front of the operator.

Mr. Woodbury has modified his process so as to obtain copper-plates suitable for deep printing in the ordinary copper-plate press, and this modification has been worked with the greatest success by Messrs. Goupil and Co., of Paris, who have kindly lent me these magnificent specimens of their work.

A gritty powder is added to the gelatinous mixture employed for making the relief, and, when the relief is made, it is found to be more or less rough, from the projection of the gritty particles. The relief is then rolled against a sheet of lead, so as to make a perfect reverse in this metal. As far as form is concerned, this plate of lead is perfectly adapted for printing in the copper-plate press, the hollows left by the projecting particles of grit holding the ink to perfection. But as lead is much too soft to be used as a deep-printing plate, the leaden plate is reproduced in copper by the electrotype process, two electrotypings being, of course, necessary, one to make a reverse mould, and a second to make a cast of this mould, or a duplicate of the original leaden plate.

Lecture V.—Delivered March 19, 1878.

Collotypic Printing.

You have already seen how extended is the use of bichromated gelatine in photo-mechanical printing processes, and we now have to study a method in which the gelatine itself is used as a printing surface.

The bare principles of collotypic printing are as follows:—A plate of glass or metal is coated with a uniform layer of bichromated gelatine, and this is exposed to light under a negative. Certain parts become insoluble by the action of light, others remain soluble and capable of absorbing water. The plate is damped, and a roller, charged with fatty ink, is passed over it. Those parts which received the water, refuse the ink; and a piece of paper being laid on and pressure applied, the ink sets off on the paper, forming a print.

But more than this is true, as we have an infinite number of grades between the two extremes of water-taking parts, and of ink-taking parts; those parts which had a slight exposure to light being capable of receiving both ink and water, the proportion in which each is received depending on the extent to which the part has been acted on by light. Here is a damp collotype plate; I hold it up to the light, and those who are near can see a very feeble image. I now pass the inking roller over it a few times, and the fatty ink adheres to those parts which have been exposed to light, the amount of ink being proportionate to the extent to which the light has acted; so that a picture is built up with all its gradations of light and shade. I hold up the inked plate before the light, and you see the image distinctly. I will now hand round the inked plate, together with a similar, but uninked plate. Here is one more plate, which I take from this dish of water; this I will ink, and take an impression from it on paper. Here they are, you see. If you hand them round, you can compare the plate with the proof printed from it.

The first step in preparing the collotypic plate is to take two pieces of plate-glass, such as I have here, to put some water and flour emery on one of them, then to grind them together until the rubbing surfaces are uniformly de-polished. It is not worth while for me to go on grinding these until they are finished, but here are some finished ones which you can examine. When the plates have been sufficiently ground, they must be well rinsed, and reared up against a shelf to dry. The next thing is to prepare a mixture of seven parts of albumen, three parts of commercial water-glass solution, and ten parts of water. This mixture being made, it is churned to a froth by one of these American egg beaters. You see it only takes about two minutes to convert the whole into a froth. I now pour this froth on a paper filter, and as it breaks up it runs through. This solution is now ready to pour on the plates, and you see that it runs easily over. I now let it drain off at one corner, and allow the plate to dry in an inclined position. When dry, the plate is well rinsed in water, in order to remove all soluble matter, and is again reared up to dry. In this state the plate is covered with an extremely thin whitish film, which causes adhesion between the plate and the gelatine coating which is next applied. The sensitive gelatinous mixture is prepared by dissolving six parts of gelatine in 48 parts of water, and adding one part of ammonium bichromate, and 48 parts of alcohol. The mixture is then strained through fine muslin, and is ready for use.

Here is a metal hot plate, made double, and in the interspace water is kept boiling. Three levelling screws support one of the prepared glass plates, about an inch from the surface of the metal hot plate. The glass plate usually reaches a temperature of about 50° C. under these circumstances, and when this is the case, and the plate is quite level, all is ready for coating it with the sensitive gelatine. I now pour on the middle of the plate as much of the sensitive mixture as it will conveniently hold, and you see that it runs well over the plate, even up to the corners. I now lift up the plate quickly, drain off the excess of gelatinous mixture, give the plate a rocking motion, and put it back on the levelling screws in its old position. In about ten minutes it will be dry and ready for exposure in the printing frame, and this exposure is about equal to that which would be required to make a silver print from the same negative; but a plate which has been dried quickly requires a longer exposure than one which has been dried slowly.

Mr. Debus is now holding a dried plate against the lime light, and you merely see an even yellow tint, arising from the uniform film of bichromated gelatine. He will now hold up a similar plate which has been exposed under a negative, and you see a faint brownish image, showing all details and shades of the original. After having printed the plate under the negative, the next step is to soak the plate in cold water, in order to remove the free bichromate; and during this soaking the image becomes much fainter, as you will see when I hold this soaked plate before the lime light. During this soaking in water another change, and a remarkable one, takes place; all the exposed parts of the plate become puckered up into a multitude of little folds, which wind about in a very peculiar manner. These folds may be traced almost all over the picture, their depth being greatest on those parts which have been most exposed—at least up to a certain limit, beyond which increased exposure tends to destroy the folds. The pitch of these folds may vary from about fifty to three hundred to a linear inch, and this pitch varies according to the treatment of the plate, the kind of gelatine used, the condition of the bichromate, the length of time which the sensitive mixture is kept before use, the rapidity of drying, and other circumstances. This puckering, reticulation, or grain has much to do with the printing qualities of the plate, one with a coarse grain being easier to print from than one with a fine grain, but the results are, in general, not so good. When the plate has been soaked in water sufficiently long to remove the excess of bichromate and to develop the grain, it is taken out and allowed to dry spontaneously. The dry plate may then be kept without injury for several days, or weeks, or even months. It should be kept in a dry cool room, and, as a rule, ought not to be put away in a brightly lighted place.

We now pass on to the inking of the plate and its treatment in the press. Before use the plate should be soaked in water, in order to saturate the soluble portions of the gelatine with this fluid, and generally five or ten minutes is sufficient for this purpose. It is usual to employ the ordinary lithographic roller, and ordinary lithographic inks, for collotypic printing, and when a lithographic roller is in really first-rate condition it answers admirably; but a new lithographic roller can only be got into a sufficiently good condition by daily exercise for about a month, and the least carelessness, the drying of ink on it, or a cessation of work for a few days, will degrade it from the state of a roller suitable for collotypic work to that of an ordinary roller suitable for lithography.

Here is a form of roller which I have devised, and have found to answer admirably, as it is always ready for use. It consists of an outer cylinder of red india-rubber, made smooth on the outside by means of fine glass paper; inside this is a thickness of about three-quarters of an inch of ordinary

typographic roller composition (glue and treacle), and inside all a wooden core, provided with handles. To make this kind of roller, I put the india-rubber cylinder inside this brass mould, place the core in position, and pour in a little of this glue-and-treacle composition—just enough to seal the joint at the bottom—and when this has set I will fill the space with the glue-and-treacle mixture. When a roller of this kind is done with, the ink can be cleaned off by means of a rag moistened with a little oil of turpentine, care being taken not to use too much. The roller is then ready to be put away, and can be brought into use again at a moment's notice.

The labour of mixing stiff inks and colours, and of getting an even film on the inking slab, is considerable; but I have found that the following plan obviates all difficulty on this score. The ink is mixed up with oil of turpentine to the consistency of cream, and the colour may be modified by the addition of the artists' oil colours which are sold in tubes. In this way a thorough mixing of the colours is ensured, and when it is intended to use a portion, a piece of muslin is tied over the mouth of the bottle containing the colour, the bottle is then inverted, and the muslin-covered neck is rubbed over the inking slab. The ink thus filtered out is spread evenly by means of an ordinary typographic ink roller, and is then allowed to remain a few minutes, in order that the turpentine may evaporate. Thus is obtained a layer of ink, free from lumps, well mixed, and evenly spread. The collotypic plate, being now taken from the water, is laid on the bed of the press, this having been previously covered with a sheet of white paper, and is gently wiped with a soft piece of muslin. The inking roller being charged with ink from the slab, is gently rolled backwards and forwards, as I am now rolling, it being borne in mind that a slow rolling with heavy pressure tends to put much ink on the plate, and quick rolling with light pressure tends to take off an excess of ink. It is advisable to be provided with two inks, one rather thinner than the other, as the half tones sometimes require a thin ink to bring them fairly out. To make this thin ink, a little of the very fluid lithographic varnish (known as tint varnish or S.H. varnish) is added to the mixture of turpentine and ink. The kind of press best adapted for collotypic printing is the roller lithographic press, like those commonly used in France and Italy—a Waterloo's autographic press is very well adapted for the work—but the scraper press does not answer so well. You see that the press I am using consists merely of two rollers, with the tympan and bed riding between them.

The plate having been inked, and the paper laid on, a moist sponge is passed over the back of it. I then put on a few thicknesses of blotting paper and a sheet of india-rubber an eighth of an inch thick, shut down the tympan, and pass through the press. Here, then, is the result.

Any kind of paper may be used for collotypic printing, but if it be desired to imitate silver prints, a thin and rather soft enamel paper must be used, and the prints must be varnished with a varnish prepared by dissolving two parts of white shellac and one part of mastic in a convenient quantity of methylated spirit. The strength of the solution will depend on the effect required, and it is scarcely necessary to say that the varnish must not be allowed to chill. Here is a print; I will varnish one half of it, and when dry, you can compare the two sides.

The process which I have demonstrated to you is practically that of Professor Husnik, as set forth his invaluable work on the subject,* and if I were to give you the leading features of the various collotypic processes, I should occupy several hours in doing it. The characteristic feature of the Albertype process consists in covering the glass plate with a film composed of gelatine, albumen, and potassium bichromate, and exposing this to light through the plate of glass, so as to make that part in immediate contact with the glass insoluble, washing off the soluble portion in warm water, so as to leave a very thin film of insoluble gelatine, capable of serving as a bond between the glass and the actual printing film, which is now applied.

Mr. J. R. Sawyer, of the Autotype Company, has elaborated a process by which he has produced magnificent results, some of which you may see hanging up all round the room. You will see among these representatives of almost all classes of photographic work—ancient manuscripts, coins, architecture, landscapes, engineering works, and book illustrations. Directly opposite to me is an exceedingly fine collotypic print of Norwich Cathedral, and this is from one of Mr. Sawyer's own negatives. You will also notice a series of prints representing the great public engineering works of France, which are now being printed by the Autotype Company, under the direction of Mr. Sawyer. The production of this series, regularly and in large numbers, proves the thorough practicability of the collotype process when in careful hands.

You see before you some admirable specimens of collotypic printing, by Messrs. Braun and Co., of Dornach, Messrs. Strumper and Co., of Hamburg, and Messrs. Wright and Co., of London.

The next great step in collotypic printing is the application of steam machinery to the process; the difficulties of wiping the plate, inking, and taking off the paper, by machinery, are considerable, but these difficulties are being gradually overcome.

* Das Gesammtgebiet des Lichtdrucks. J. Husnik. 3 Mark. Hartleben, Leipzig.

Lecture VI.—Delivered March 26, 1878.

Other methods of producing photographs in pigment. Dusting-on process. Autotype printing.

You will remember that, last week, I spoke of the the use of india-rubber rollers for the inking of collotype plates, and that I recommended a roller made with a thin surface of red india-rubber on a body of the glue and treacle composition used for typographic rollers. At the conclusion of the lecture, Mr. Dallas informed me that Messrs. Blades, East, and Blades, of Abchurch-lane, have recently introduced into commerce a roller consisting of a thick layer of red vulcanised india-rubber on a rigid stock. These rollers are made under a patent of Mr. Lanham, manager to the above-mentioned firm, and will, I am convinced, prove of very great value to lithographers as well as to collotypic printers. The manufacturers have kindly lent me some specimens of their rollers, which are now on the table.

Up to the present time we have been studying the means of producing, by the agency of photography, printing surfaces from which copies might be obtained without any further intervention of light; but in this, the last lecture of the series, I want to call your attention to some methods for the production of pictures in pigment, which necessitate a direct and separate action of light for the production of each picture.

Here is a glass plate, and I pour on it a mixture containing 25 parts of glucose, 4 of honey, and 4 of ammonium bichromate, dissolved in 120 of water. I lay the plate on the hot-water apparatus, and it will be dry in a few minutes. If the dried plate is exposed to the atmosphere, it will absorb moisture, and the whole surface will become sticky. Now that the plate is dry, and while it is warm, I will place it behind a transparency and allow a strong light to shine on it through the transparency. The joint action of light and ammonium bichromate tends to make the honey and glucose insoluble; or, at any rate, it prevents these materials from absorbing moisture from the air, as they tend to do naturally. Let us now take the plate out of the frame and examine it. A very faint image may be traced thereon, but only those of you who are near can see it. Now, what is happening to this plate? Those parts which were protected from the light are absorbing moisture from the air, the honey and glucose being here unaltered, while those parts which were exposed to the full action of the light refuse to absorb moisture, and those parts which have been protected from the action of a part of the light, absorb an amount of moisture proportionate to the degree of shade afforded by the half tones of the transparency. Now note the effect of dusting powdered black-lead over the plate, and rubbing it on with a soft brush. Those parts which are dry refuse to take the black-lead, while those parts which are moist hold an amount of black-lead proportionate to the degree of moisture. Now look at our plate, and you will see that there is a picture showing all degrees of light and shade, the picture being formed of black-lead, held by the various degrees of moisture absorbed from the air. The next step is to coat the plate with collodion, and to immerse it in water, in order that the yellow ammonium bichromate may diffuse out. Other pigments than black-lead may be employed, and the pictures may be made on paper or other materials, but the dusting-on process, although interesting as a means of producing permanent photographs, is not worked commercially to any great extent.

We now pass on to the study of a process of much greater importance than the dusting-on method, namely, the so-called carbon process, or the autotype method. The first step in this process consists in coating one side of paper with a tolerably thick layer of gelatine, to which a little sugar has been added, together with sufficient pigment to strongly colour the mixture. Here is a piece of the "pigmented tissue," as it occurs in commerce. To prepare it, about three parts of gelatine, and one part of sugar, are dissolved in water, and the pigment is added in sufficient quantity. A band of paper is then drawn over the surface of the mixture in such a way as to coat its surface with a uniform layer of the composition. The pigmented tissues are prepared on a large scale by the Autotype Company and others, and few will care to prepare their own tissue, excepting for experimental purposes.

To make the tissue sensitive to light, it is soaked in a solution of potassium bichromate, containing about three and a half per cent. of the salt. You see that this piece of tissue has now become quite flaccid from the absorption of the solution. So I scrape off the excess of solution by drawing the tissue over the edge of the dish, take it out, and hang it up to dry. When dry it will be ready for exposure under the negative. Here is some which has been previously dried, and I will put a piece under this negative and expose to the action of a bright light. In the ordinary process of silver printing, one can watch the progress of the operation, and can easily tell when sufficient exposure has been given. Not so in the case of the tissue, as it undergoes no visible change by exposure to light. Here is a little tin box having a small glass window in its lid, and a strip of sensitive silver paper can be drawn forward under this window. The lid having been shut down so as to press on the strip of silver paper, the tin box is exposed to light simultaneously with the printing frame containing negative and tissue, and as soon as the silver paper has acquired a certain standard tint or degree of darkness, it is considered that the tissue has had one unit of exposure. The silvered paper

is then drawn forward, so as to expose another portion, and so on until as many units of exposure have been given as the tissue is known to require when exposed under the negative in hand. This is quite easy in practice, as a little experience will enable one to judge how many units of exposure, or "tints," will be required by each negative, and one guide-box, or "actinometer," serves for any number of printing frames. The tissue which I just placed under a negative has now had sufficient exposure to light; I take it out, soak it in water until it is soft, and then, while it is still in the water, I bring it in contact with a piece of paper which has been coated over with a thin layer of insoluble gelatine, so as to make it impervious to water. The tissue and the impervious paper are drawn out of the water together, and an application of the squeegee now removes the excess of water which remains between the two surfaces, and the exposed tissue adheres to the impervious paper. Let us allow them to remain in contact for a few minutes, in order that the tendency to adhere may become greater.

Bear in mind that the bichromatised and pigmented gelatine becomes insoluble by the action of light shining through the negative, and the depth to which this insolubility extends is dependent on the amount of light which has acted on it. On those parts of the tissue which have been exposed to much light, a thick layer of gelatine is made insoluble, while on those parts which have been exposed to only a little light, the insoluble layer is very thin.

Now, we want to wash away the soluble portions of the gelatine from the exposed tissue, and to leave the portion made insoluble by the action of light, just as in the Woodburytype process; but if the exposed tissue were put directly into hot water, the insoluble image would become undermined by the dissolving away of the gelatine from underneath it, and it would become destroyed for want of a support sufficiently strong to hold it together. You can now understand why the exposed tissue was mounted on a piece of impervious paper, this being intended to hold together the insoluble gelatine image during the treatment with warm water. Here is the tissue, which I mounted on a piece of the impervious paper, or single transfer paper. Notice the effect of putting it into a dish of warm water. You see that the soluble gelatine in which the insoluble image is embedded melts and exudes from under the edges of the paper, while the application of a very little force will now enable us to separate the two papers, viz., that on which the tissue was originally made, and the impervious paper on which the tissue was mounted. Under these circumstances, the insoluble image naturally adheres to the impervious paper, or single transfer paper, but it is at present clogged up by some of the soluble gelatine, which must be removed by rinsing with warm water. You see that this soon dissolves away, leaving the image on the single transfer paper. Here it is. This image consists of varying thicknesses of gelatine made insoluble by the joint action of light and a bichromate, but as the gelatine contains a black pigment (carbon), it shows on the paper as a picture in black and white. This is the simplest form of the carbon or autotype process; it is known as the single transfer process, and, as a little consideration will show you, it requires a reversed negative; that is to say, a negative in which the sides of the picture are reversed, left-hand being where right-hand should be, and right where left. This disadvantage is obviated by the so-called double transfer process. According to this method, the picture is not developed on the support which is ultimately to hold it, but on a temporary support, from which it is removed by the application of a sheet of adhesive paper.

Yonder, at the other end of the table, stands Mr. Foxlee, surrounded by carbon printing materials of every kind, and he has kindly consented to demonstrate the principal phases of the carbon process with some materials and partly finished prints, for which I am indebted to the Autotype Company. I see that, while I have been talking, Mr. Foxlee has been busy; he has mounted some pieces of exposed tissue on waxed zinc plates, some on collodionised opal glass, some on single transfer paper, and others on a material known as Sawyer's flexible support, and which I shall describe to you directly. To all of these the wet tissue adheres perfectly well, and as the prints are now ready for development, Mr. Foxlee is putting them into trays of warm water. Notice how he strips the paper off as the soluble gelatine dissolves, and how the pictures will gradually unfold when he rinses them with warm water.

I want you now to take notice of the flexible support introduced by Mr. Sawyer, the talented director of the Autotype Works. Its basis consists of hard paper coated with a layer of insoluble gelatine. This is floated on an alkaline solution cf shellac, which softens the gelatine on the surface bonds with it, and forms a thin film of varnish over it. When dry, the flexible support is rubbed over with a weak solution of wax and resin in oil of turpentine, in order to prevent the possibility of permanent adhesion between the flexible support and the gelatine picture. The great advantage of this support consists in the fact that the fine details of the gelatine picture are not crushed against a rigid surface in the mounting and subsequent treatment. This will be illustrated further on.

Mr. Foxlee has now finished developing his pictures—those developed on single transfer paper are finished, as after development they only require rinsing in cold water, a dip in alum solution to harden the gelatine, and then a second rinse to remove the excess of alum. You see that among the single transfer prints which Mr. Foxlee has developed are some very fine large portraits, but Mr. Foxlee makes large prints as easily as others make small ones; he thinks nothing of making them three feet by four feet, or even larger. Now, here are the prints which Mr. Foxlee has developed for double transfer—some on zinc plates, some on Sawyer's flexible support, and others on opal glass. I see that he has a number of pieces of the so-called double transfer paper in a dish of warm water before him. This paper is coated on one side with gelatine, to which a little alum or chrome alum has been added, and when it is put into warm water the surface becomes sticky, but the gelatine does not dissolve. On each of these prints, which have been developed

on the various supports, Mr. Foxlee is placing a sheet of the wet and sticky double transfer paper, and after having ensured contact by means of the squeegee, he puts them aside to dry, and when they are dry it will be found that the paper can be easily stripped from the temporary support, carrying the print with it. In order to illustrate this, Mr. Foxlee has provided himself with some transferred prints, already dried, and ready to strip from the temporary support. You see that Mr. Foxlee is now stripping the prints from zinc plates; he just inserts his thumb-nail under one corner, and then a slight pull brings the print off. Now he is similarly stripping prints which have been developed on collodionised opal glass. Notice what a fine enamel-like lustre they have. Next, he will separate the prints from Sawyer's flexible support. You see how easily they separate, and if you carefully examine the flexible support from which a print has been separated, you will be able to trace a faint intaglio image of the print, showing how the image sinks into, and is protected by, the flexible support. The single transfer process and tissue making are now open to all; but the double transfer method and the manufacture of Sawyer's flexible support are subject to patents held by the Autotype Company; licenses for the working of double transfer are, however, granted on almost nominal terms.

Mr. Foxlee will now illustrate to you the method of making carbon pictures on ivory and on artist's canvas. He has developed pictures on the flexible support, and while they are wet he lays them down on the ivory and on the canvas, which, by-the-bye, have been previously prepared with a thin film of partially insoluble gelatine, and makes contact by means of the squeegee. When dry, the flexible support can be peeled off, leaving the print on the ivory or on the canvas. You see that Mr. Foxlee is now stripping the flexible support from some specimens which he has previously prepared. Very beautiful transparency pictures can be produced by the carbon process; it being merely necessary to squeegee the exposed and wet tissue on to a piece of collodionised glass, and after a few minutes, to develop in warm water. Mr. Foxlee is now developing some, and when they are finished I will exhibit them to you by means of the magic lantern. The process I have described to you is generally known as the carbon process, it having arisen out of an earnest desire to obtain non-fading photographs; and as carbon is the type of a non-fading pigment, it was naturally used at first, either in the form of a lamp-black or of Indian ink. As time went on, people wanted other tints, and it was considered especially desirable to imitate the purple tint of a gold-toned silver print. This was done to perfection by the use of a mixture of lamp-black, indigo, and cochineal lake, but, unfortunately, the prints so coloured were found to change their tint owing to the fading of the cochineal lake. Attempts were soon made to replace the fugitive cochineal colour by permanent reds, and notably by madder red or alizarine, but until recently with only partial success, as ordinary madder lakes work mischief in the tissue. Mr. Sawyer has, however, recently overcome all difficulties with regard to the use of alizarine in tissue, and alizarine is now used in all the tissue of the Autotype Company, which imitates the "photographic tone," or series of tints shown by silver prints.

The kindness of many eminent carbon printers has enabled me to show you a splendid collection of prints to-night. The Autotype Company have lent me several hundred of their well-known and admirable productions, ranging in dimensions from four feet high to pin or brooch size. Messrs. Braun and Co., of Dornach, have kindly lent me specimens which are of the first order, and I want you to especially notice the excellence of two untouched portraits kindly lent by the Woodburytype Company. Among the more recent carbon painters we have Mr. Witcombe, of Salisbury, who has sent a very fine collection of small prints, but as they arrived too late to be displayed, I have placed them on the table. You will see over yonder a frame containing some prints made by a process due to Sir Thomas Parkyns. The carbon prints being covered with a film of coloured collodion, very striking effects are produced, imitating moonlight and other effects.

Mr. Le Neve Foster has lent me a carbon print made by Mr. Pouncy twenty years ago, and if you look at it you will see that in detail and delicacy of gradation it is quite equal to the productions of more recent times; and I have here some carbon prints which were made by Mr. Foxlee, nearly as long ago. I should like you to look at these, as they are an illustration of what was done during the infancy of carbon printing.

In these lectures I have not attempted to give anything like a history of photo-typography; I have not even mentioned many important processes. Had I referred to all, the six lectures would have been merely an index to the work which has been done. I wish I had been able to give you more details of the processes described, but you must bear in mind that days rather than hours are required for properly demonstrating the simplest photo-mechanical process, and real working and practical demonstrations can only be given in the quiet of the laboratory, and to a very small number of people at a time.

Before you go, I want you to appreciate the help which Mr. Barker and Mr. Debus have afforded me, not only in work incidental to the delivery of the lectures, but also in the work of preparing materials for them. Do not forget the thanks which are due to Mr. Foxlee, for his admirable demonstration of the carbon process.

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